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(19)

(54) IMPROVEMENTS IN OR RELATING TO ELECTROLUMINESCENT DISPLAY DEVICES AND THEIR MANUFACTURE

(71) We, THE GENERAL ELECTRIC COMPANY LIMITED, of 1 Stanhope Gate, London W1A 1EH, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electroluminescent display devices of the type (hereinafter referred to as the type specified) including a display panel consisting essentially of a light-transmissive substrate and, supported on the substrate, a layer of electroluminescent phosphor and two electrodes in contact with the phosphor layer, at least one of the electrodes being formed in a plurality of separate sections, which arrangement of phosphor layer and electrodes constitutes the display area of the panel, and the device including also contacts and conducting leads for connection of the electrodes and/or electrode sections to a source of electric current supply, through a suitable operating circuit arrangement, for the application of an operating voltage across the panel. The invention is more particularly, but not exclusively, concerned with devices of this type which are adapted for operation by the application of a unidirectional voltage, either continuous or pulsed, between the electrodes. The invention also relates to methods of manufacturing the devices described.

The electroluminescent panel may be of the so-called "sandwich" form, wherein the phosphor layer is sandwiched between a front electrode and a back electrode, the front electrode being light-transmissive and usually consisting of a transparent electrically conducting coating, for example of tin oxide or indium oxide, on the substrate, and all parts of the phosphor layer which are disposed between the two electrodes being excitable to luminscenc by the applied voltage; in a device of the type with which the present invention is concerned, when the panel is of the sandwich form as defined above, at least the front electrode is formed in a plurality of separate sections. Alternatively, the panel may be of the so-called "gap-cell" form, wherein both of the electrodes are located on the same side of the phosphor layer, one or both of the electrodes being formed in a plurality of separate sections, and portions of the respective electrodes being arranged adjacent to one another with only small gaps between them: in this case only those portions of the phosphor layer which are located in gaps between adjacent sections of the two electrodes, or between one electrode and sections of the other, are excitable to luminescence in operation of the device.

It has been proposed to incorporate, in an electroluminescent panel of either the sandwich type or the gap-cell type, a layer of insulating material disposed so as to insulate portions of the phosphor layer, which are not required to emit light in operation of the panel, from one or both of the electrodes. Such an insulating layer has the effect of reducing or preventing the occurrence of leakage current at the edges of the light-emitting areas in operation of the device, and can also be used for delineating the light-emitting areas.

The display panel in a device of the type with which this invention is concerned incorporates an array of elements, delineated by the separate electrode sections and/or by an insulating layer as aforesaid, and capable of being independently energised singly or in various combinations, for the production of selected displays. One example of this type of device comprises a digital display panel, which is composed of

a multiplicity of elements arranged in groups, each group consisting of several elements so arranged that, on selective energisation and resulting light emission from one or more of the elements of the group, any desired digit from 0 to 9 can be displayed, and the arrangements of elements in all the groups usually being identical. The display elements are conveniently delineated by electrode sections in the form of a light-transmissive electrically conducting coating on the substrate, and each such electrode section is provided with a conducting lead to a contact for connection to a source of electric current supply via a suitable operating circuit, which may include an arrangement for multiplexing the digits of the display. Thus for a display consisting of a relatively large number of digits, a large number of contacts on the substrate and a similarly large number of external leads therefrom to the operating circuit will be required.

It is an object of the present invention to provide an improved construction of electroluminescent display device of the type specified, incorporating an array of a multiplicity of elements corresponding to electrode sections, whereby the number of external leads required for connection of the electrode sections to an operating circuit can be reduced.

According to the invention, an electroluminescent display device of the type hereinbefore specified includes a light-transmissive, electrically conducting coating formed on a substrate in a pattern including a multiplicity of electrode sections arranged to form the required elements in a display area of the panel, said electrode sections either constituting one of the electrodes of the device or being arranged in two sets so as to constitute both electrodes of the device, said pattern also including leads extending from the respective electrode sections towards the edge of the substrate and a plurality of contact areas adjacent to the edge of the substrate; an insulating coating overlying said leads and delineating the periphery of each portion of the display area corresponding to a said element or a group of said elements, the regions of the insulating coating which lie outside the display area having a plurality of apertures through each of which a small area of one of said leads is exposed, said lead being so exposed through not more than one such aperture; a plurality of strips of electrically conducting material overlying the insulating coating in the said regions outside the display area and disposed transverse to the said leads, each of said conducting strips overlying a plurality of the said apertures in the insulating coating, so as to contact the leads therethrough, and being connected to one of said contact areas adjacent to the edge of the substrate; a phosphor layer overlying at least the said delineated portions of the display area; and where the said multiplicity of electrode sections constitutes only one of the electrodes of the device, a second electrode or set of electrode sections overlying the phosphor layer.

In a preferred form of the invention the substrate is of rectangular shape, and the leads from the electrode sections are arranged substantially parallel to one another, running from the respective electrode sections towards the longer edges of the substrate, while the transverse conductive strips overlying the insulating coating lie parallel to the longer edges of the substrate and are connected to contact areas which are disposed adjacent to the shorter edges of the substrate. Additional contact pads of conducting material are usually provided on the contact areas, for facilitating connection of the contact areas and hence of the transverse conducting strips to an operating circuit.

The light-transmissive, conducting pattern formed on the substrate may include one or more transverse strips, parallel to the transverse conducting strips overlying the insulating layer and disposed between the latter strips and the edge of the substrate. These transverse strips formed directly on the substrate thus constitute the outermost members of groups of transverse conducting strips, and are also connected to contact areas adjacent to the edge of the substrate. Some of the leads from the electrode sections are extended to join these outermost strips; it will therefore not be necessary to provide apertures in the insulating coating to permit connection of these particular leads to transverse conducting strips.

Each of the transverse conducting strips can be connected to leads from a plurality of electrode sections which are required to be energised simultaneously. In a particularly advantageous application of the invention, where the display elements are arranged in a number of similar groups, as in a digital display, the apertures in the insulating coating and the disposition of the transverse conducting strips are so arranged that each such strip is in contact with a lead from one display element in each group, the elements thus connected to any one such strip all occupying the same position in their respective groups, for example forming corresponding portions of digits. This arrangement enables multiplexing of the digits to be carried out on the display panel itself, thus eliminating the multiplicity of conductors, external to the panel, which would otherwise be re-

quired for connecting the electrode leads on the substrate to an operating circuit, since only one external lead to each transverse conducting strip will be required in respect of the front electrode sections in the case of a sandwich panel, or in respect of the sections of each electrode in the case of a gap-cell panel.

In a device in accordance with the invention incorporating a sandwich panel, the electrode sections included in the light-transmissive conducting pattern on the substrate constitute the front electrode, and a back electrode is provided, overlying the phosphor layer, usually formed in a plurality of sections each covering one of the portions of the display area which are delineated by the insulating coating, for separate energisation of the elements or groups of elements of the display, a lead for connection of each section of the back electrode to an operating circuit being provided. In the case of a device incorporating a gap-cell panel, both electrodes are formed in a multiplicity of sections included in the light transmissive conducting pattern on the substrate, the patterns of the two electrodes being so arranged that each element of the display is formed by a gap between adjacent sections of the respective electrodes, and two sets of transverse conducting strips are provided, the two such sets being arranged to contact the leads from the sections of the two electrodes respectively.

The invention is especially suitable for application to a digital display panel of the sandwich type. In the construction of such a panel, in accordance with the invention, the front electrode sections are arranged in a number of identical groups each corresponding to a digit, for example each group consisting of seven bars so arranged that any digit from 0 to 9 can be formed from them, the area of each digit is delineated by the insulating coating, and the phosphor layer and back electrode are formed in sections covering the respective digit areas. The number of transverse conducting strips (including any such strips incorporated in the conducting pattern on the substrate) required will be equal to the number of front electrode sections forming each digit, the front electrode sections in the corresponding position in all the digit areas being connected to the same transverse strip, and a separate transverse strip being provided for each set of such corresponding front electrode sections.

The insulating coating suitably consists of one or more layers of photoresist material. Preferably at least the part of the insulating coating adjacent to the display elements and immediately surrounding the dilineated portions of the display area consists of a transparent film of material which is either colourless or of a light colour substantially the same as the body colour of the phosphor layer, so that at least the display area of the panel has a substantially uniform appearance, as viewed from the front of the panel, when none of the display elements are illuminated.

The parts of the insulating coating overlaid by transverse conducting strips are preferably thicker than the parts immediately surrounding the display area, in order to ensure that adequate insulation is provided between the conducting strips and the underlying leads, except where contacts are formed between the strip and leads through the apertures in the insulating coating. This additional thickness is conveniently provided by applying one or more extra layers of insulating material on the areas to be overlaid by the conducting strips: such extra layers are not necesarily composed of the colourless or light coloured material preferably used for the display area of the panel.

The greater part of the device, comprising the phosphor layer, electrodes, insulating coating, and transverse conducting strips, is preferably encapsulated by means of an enclosure hermetically sealed to the substrate, at least that part of the encapsulating structure which is in contact with and sealed to the substrate, and thus is in contact with parts of the conducting pattern on the substrate and possibly with the transverse conducting strips and contacts, being composed of insulating material, suitably glass or ceramic. Suitable forms of encapsulating structure are, for example, a glass or ceramic dome, or a glass frame covered by a metal plate, or a metal dome insulated from the substrate conductors, for example by an oxide layer. Preferably the encapsulating enclosure is filled with a dry atmosphere consisting of an inert gas containing a small proportion of oxygen, and contains a getter for water vapour.

In the case of a sandwich panel, the lead or leads from the back electrode or sections thereof may, if desired, be in the form of strips of metal or metal paint connected to contacts situated on the substrate. Preferably, however, to avoid problems of space and insulation on the substrate, these leads are sealed through an insulating portion of the encapsulating structure, the latter thus providing support and insulation for the leads: leads so supported may consist of robust metal strips bent to form spring contacts with the electrode sections.

The preferred method of manufacturing a device in accordance with the invention includes the steps, in order, of forming the

required pattern of light-transmissive electrically conducting material on the substrate, depositing one or more layers of insulating material on the appropriate regions of the substrate, apertures being formed in the insulating coating as required, depositing the phosphor layer and (in the case of a sandwich panel) the back electrode over the requisite part or parts of the display area, depositing transverse strips of electrically conducting material so as to overlie the apertures in the insulating coating in the regions outside the display area and depositing contact pads on the contact areas adjacent to the edge of the substrate, and sealing an encapsulating structure to the edge regions of the substrate, a lead or leads from the back electrode or sections thereof, if present, being sealed through an insulating portion of the encapsulating structure before or during the encapsulating procedure. Finally, the device is brought into the requisite condition for operation by a suitable electric forming process, carried out in known manner, to develop the electroluminescent properties of the panel and increase its electrical resistance.

The substrate is usually of glass, and the conducting coating thereon, suitably consisting of tin oxide, and the overlying insulating layer or layers, are conveniently formed in the required patterns by photoresist techniques. The phosphor layer and the back electrode may be formed by any known convenient techniques, for example the phosphor layer may be deposited by spraying a phosphor powder suspension, and the back electrode may be formed by spraying a silver powder suspension or by evaporating aluminium, in each case through a suitable mask; alternatively both the phosphor layer and the back electrode may be applied by screen printing.

An electroluminescent display device in accordance with the invention can be operated by means of a drive circuit of known kind. In one convenient arrangement, at least part of the drive circuitry, in the form of printed circuits carried on chips of insulating material, can be mounted on the same substrate as the display panel, the substrate in this case being somewhat larger in area than that required to accommodate only the display panel and associated leads, transverse conducting strips and contact areas. The circuitry mounted on the display substrate in this manner can then be enclosed in the display encapsulation.

A specific form of electroluminescent display device in accordance with the invention, and the method which we have employed for the manufacture of the device, will now be described by way of example, with reference to the accompanying drawings, in which

Figure 1 shows a device including a nine digit display panel, in front plan view, that is to say as observed through the transparent substrate,

Figure 2 is a back plan view of the device of Figure 1, prior to encapsulation, on a smaller scale, and

Figure 3 is a perspective view of the completed, encapsulated, device, also on a smaller scale.

Like parts in the different figures of the drawings are indicated by the same reference numerals.

Referring to Figure 1, in which only the two end members of the series of nine digits are shown, a rectangular glass substrate 1 has formed on it a transparent tin oxide coating comprising front electrode sections 2, leads 3, 4, 5, 6, 7, 8, 9 and 10 running generally parallel to one another from the electrode sections towards the longer edges of the substrate, two strips 11 and 12 lying transverse to the leads, and contact areas 13, 14, 15, 16, 17, 18, 19 and 20 on the shorter edge regions of the substrate, the strips 11 and 12 being directly joined to the contact areas 13 and 16 respectively. The electrode sections 2 constitute the display elements, consisting of seven bars and a dot for each digit, and have been shaded in order to show the form of the digits clearly. The seven digits which are not shown in Figure 1, intervening between the two end digits, are of identical construction to those shown: corresponding leads and other components for the different digits are indicated by the same reference numerals.

A transparent insulating coating overlies the leads and surrounds the area occupied by each digit delineating the ouer peripheries of the electrode sections: as shown in Figure 1, each electrode section is clearly distinguished, by the shading, from its associated lead. The insulating coating consists of a central portion 21, covering the leads in the display area of the panel, and composed only of a film of colourless photoresist, and two outer portions 22 composed of the same colourless photoresist overlaid by an additional layer of a more highly insulating photoresist, which may be coloured. The outer portions 22 of the insulating coating have apertures 23, 24, 25, 26, 27, 28 formed over outer end portions of the leads 3, 5, 6, 7, 8 and 10 respectively.

Transverse strips of silver paint 29, 30, 31, 32, 33 and 34, shown by broken lines behind the leads and insulation, lie on the outer portions 22 of the insulating coating, parallel to the strips 11 and 12, in such positions that each silver strip overlies a

set of apertures in the insulating coating through which corresponding leads of all the digits are exposed: thus the leads 3 of all the digits are connected to the transverse strip 31 through the apertures 23, and hence to the contact area 18, and similarly all the leads 5, 6, 7, 8, 10 are connected respectively to the strips 29, 30, 34, 33, 32 through the apertures 24, 25, 26, 27, 28, and hence to the respective contact areas 17, 14, 20, 15 and 19. The leads 4 and 9 are joined directly to the conducting strips 11 and 12 respectively. Contact pads 35, composed of silver paint, are provided on the outer edges of all the contact areas.

In Figure 2, which shows the back view of the whole panel without any encapsulating enclosure, only those parts of the transparent conducting pattern on the substrate which lie outside the insulating coating, namely the strips 11 and 12 and the contact areas 13 to 20 inclusive, are shown: the leads, which are visible through the insulating coating, have been omitted in the interests of clarity of the drawing. The transverse conducting strips 29 to 34 are fully visible, overlying the outer portions 22 of the insulating coating and terminating on the contact areas 17, 14, 18, 19, 15 and 20 respectively. This Figure also shows the back electrode in the form of separate sections 36 covering the areas of the respective digits and overlapping the edge portions of the insulating layer 21 which delineate the digits. The phosphor layer also consists of sections identical in area with, and underlying, the back electrode sections 36, and therefore is not visible in the view shown in Figure 2, but is seen at 36a in Figure 1.

Figure 3 shows the completed device, with an encapsulating structure consisting of a glass frame covered by an aluminium plate 39. The glass frame is formed in two sections, 37 and 38, fused together with leads to the back electrode sections, in the form of strips 40 of an alloy consisting of 29% nickel, 17% cobalt and 54% iron, sealed through the junction between the two glass sections 37 and 38: the inner ends of the leads (not shown in the drawing) are bent to provide spring contacts with the electrode sections.

In the manufacture of the device described above with reference to the drawings, one side of a glass plate, to constitute the substrate, is first coated with a film of tin oxide in known manner, and this film is coated with a positive photoresist, which is then exposed to ultra violet radiation through a mask delineating the pattern of the areas of tin oxide film which are to be removed. The exposed parts of the photoresist layer are developed and thus removed, and the tin oxide film in these areas is then removed by a known etching process. The residual photoresist is then exposed and removed by developing, leaving the desired tin oxide pattern on the substrate.

The two layers of insulating material are then applied to the substrate: the first, colourless, layer consists of the photoresist manufactured by Kodak Limited and sold under the Trade Mark "KMER", and the second layer consists of the photoresist manufactured by Shipley Limited and sold under the Trade Mark "AZ111". The layers are applied successively, in each case by coating the whole substrate by dipping, and then removing the unwanted areas by exposing them to ultra violet radiation through a mask covering the areas to be retained, and developing the exposed areas: thus the first layer is removed from the requisite areas for delineating the digits and for forming the apertures through which the leads are to contact the transverse conducting strips, and the second layer is removed from the whole of the display area as well as from the areas corresponding to the said apertures. The residual photoresist of each layer is finally baked at a temperature of 150°C.

A continuous layer of a zinc sulphide phosphor is then applied over the area occupied by all the digits, by spraying a phosphor powder suspension through a suitable mask, and is dried in an oven. A back electrode is applied over the whole of the phosphor layer, by spraying a suspension of silver powder through the mask used for the phosphor layer, and is also dried. The phosphor and back electrode layers are then scribed simultaneously into nine portions, to provide separate sections for the individual digits. The transverse conducting strips overlying the insulating layers, and the contact pads on the edges of the substrate, are formed simultaneously by the application of silver paint by a screen printing process.

For encapsulation of the device, two preformed glass frames of the same shape as, but of slightly smaller area than, the substrate, are fused together around their perimeters, the back electrode leads being sealed through the junction between the two frames along one side, as shown in Figure 3, and the composite frame is attached to the substrate by means of a suitable adhesive, for example an epoxy resin adhesive. A water vapour getter consisting of molecular sieve material (not shown in the drawings), in pelleted or powder form, is placed within the glass frame, which is then covered by an aluminium plate: the aluminium plate 39 is sealed to the composite glass frame with the epoxy resin adhesive, this final sealing operation being

carried out in an atmosphere of dry nitrogen containing 2% by volume of oxygen.

Finally the device is subjected to a forming process consisting in the initial application of a potential of 10 volts between the electrodes, for a few minutes, and then gradually increasing the applied voltage to 100 volts.

It will be seen that, as a result of the incorporation of the transverse conducting strips 11, 12, 29, 30, 31, 32, 33 and 34 in the construction of the display panel described above with reference to the drawings, the total number of leads required for connection of the device to a drive circuit is only 17, one lead being attached to each of the contact areas 13, 14, 15, 16, 17, 18, 19 and 20, and one to each of the nine back electrode sections 36 covering the respective digit areas. In contrast to this, a nine digit display device of conventional construction would require 81 leads for connection in a corresponding manner to a drive circuit.

WHAT WE CLAIM IS:—

1. An electroluminescent display device of the type hereinbefore specified, which includes a light-transmissive, electrically conducting coating formed on a substrate in a pattern including a multiplicity of electrode sections arranged to form the required elements in a display area of the panel, said electrode sections either constituting one of the electrodes of the device or being arranged in two sets so as to constitute both electrodes of the device, said pattern also including leads extending from the respective electrode sections towards the edge of the substrate and a plurality of contact areas adjacent to the edge of the substrate; an insulating coating overlying said leads and delineating the periphery of each portion of the display area corresponding to a said element or a group of said elements, the regions of the insulating coating which lie outside the display area having a plurality of apertures through each of which a small area of one of said leads is exposed, each lead being so exposed through not more than one such aperture; a plurality of strips of electrically conducting material overlying the insulating coating in the said regions outside the display area and disposed transverse to the said leads, each of said conducting strips overlying a plurality of the said apertures in the insulating coating, so as to contact the leads therethrough, and being connected to one of said contact areas adjacent to the edge of the substrate; a phosphor layer overlying at least the said delineated portions of the display area; and where the said multiplicity of electrode sections constitutes only one of the electrodes of the device, a second electrode or set of electrode sections overlying the phosphor layer.

2. A display device according to Claim 1, wherein the substrate is of rectangular shape, the leads from the electrode sections are arranged substantially parallel to one another, running from the respective electrode sections towards the longer edges of the substrate, and the transverse conductive strips overlying the insulating coating lie parallel to the longer edges of the substrate and are connected to contact areas which are disposed adjacent to the shorter edges of the substrate.

3. A display device according to Claim 1 or 2, wherein the said light-transmissive, conducting pattern formed on the substrate includes one or more transverse strips, lying parallel to the said transverse conducting strips overlying the insulating layer, disposed between the latter strips and the edge of the substrate so as to form the outermost members of groups of transverse conducting strips, and connected to contact areas adjacent to the edge of the substrate, and wherein some of the leads from the electrode sections are extended to join said outermost transverse strips.

4. A display device according to Claim 1, 2 or 3, wherein each of said transverse conducting strips is connected to leads from a plurality of electrode sections which are required to be energised simultaneously.

5. A display device according to Claim 4, wherein the display elements are arranged in a number of similar groups, and the apertures in the insulating coating and the disposition of the transverse conducting strips are so arranged that each such strip is in contact with a lead from one display element in each said group, the elements thus connected to any one such strip all occupying the same position in their respective groups, whereby multiplexing of the said groups can be carried out by means of said transverse strips.

6. A display device according to any preceding Claim, wherein the display panel is of the sandwich form, as hereinbefore defined, and wherein the front electrode is constituted by the electrode sections included in the light-transmissive conducting pattern on the substrate, and the back electrode overlies the phosphor layer.

7. A display device according to Claim 6, wherein the back electrode is formed in a plurality of sections each covering one of the portions of the display area which are delineated by the insulating coating, and leads are provided for connection of the respective sections of the back electrode to an operating circuit.

8. A display device according to any of the preceding Claims 1 to 5, wherein the

display panel is of the gap-cell form as hereinbefore defined, and wherein both electrodes are formed in a multiplicity of sections included in the light-transmissive conducting pattern on the substrate, the patterns of the two electrodes being so arranged that each element of the display is formed by a gap between adjacent sections of the respective electrodes, and two sets of transverse conducting strips being provided, the two such sets being arranged to contact the leads from the sections of the two electrodes respectively.

9. A display device according to Claim 7, which comprises a digital display panel, wherein the front electrode sections are arranged in a number of identical groups each corresponding to a digit, the area of each digit is delineated by the insulating coating, the phosphor layer and the back electrode are formed in sections covering the respective digit areas, and the number of transverse conducting strips incorporated in the device is equal to the number of front electrode sections forming each digit, the front electrode sections in the corresponding position in all the digit areas being connected to the same transverse strip, and a separate transverse strip being provided for each set of such corresponding front electrode sections.

10. A display device according to any preceding Claim wherein the said insulating coating consists of one or more layers of photoresist material.

11. A display device according to any preceding Claim wherein at least the part of the insulating coating adjacent to the display elements and immediately surrounding the delineated portions of the display area consists of a transparent film of material which is either colourless or of a light colour substantially the same as the body colour of the phosphor layer.

12. A display device according to any preceding Claim wherein the parts of the insulating coating overlaid by transverse conducting strips are thicker than the parts thereof immediately surrounding the display area.

13. A display device according to any preceding Claim wherein the phosphor layer, electrodes, insulating coating, and transverse conducting strips are encapsulated by means of an enclosure hermetically sealed to the substrate, at least that part of the encapsulating structure which is in contact with and sealed to the substrate being composed of insulating material.

14. A display device according to Claim 13, wherein the said encapsulating enclosure is filled with a dry atmosphere consisting of an inert gas containing a small proportion of oxygen, and contains a getter for water vapour.

15. A display device according to Claim 13 or 14, which is of the sandwich form as hereinbefore defined, wherein the lead or leads from the back electrode or sections thereof is or are sealed through an insulating portion of the encapsulating structure.

16. A method of manufacturing an electroluminescent display device according to Claim 15, which includes the steps, in order, of forming the required pattern of light-transmissive, electrically conducting material on the substrate, depositing one or more layers of insulating material on the appropriate regions of the substrate, apertures being formed in the insulating coating as required, depositing a phosphor layer and, in the case of a display panel of the sandwich form as hereinbefore defined, a back electrode over the requisite part or parts of the display area, depositing transverse strips of electrically conducting material so as to overlie the apertures in the insulating material in the regions outside the display area, depositing contact pads on the contact areas adjacent to the edge of the substrate, sealing an encapsulating structure to the edge regions of the substrate, a lead or leads from the back electrode or sections thereof, if present, being sealed through an insulating portion of the encapsulating structure before or during the encapsulating procedure, and subjecting the completed device to an electric forming process.

17. An electroluminescent display device according to Claim 1, including a nine digit display panel, substantially as shown in, and as hereinbefore described with reference to, the accompanying drawings.

18. A method of manufacturing an electroluminescent display device according to Claim 1, including a nine digit display panel, carried out substantially as hereinbefore described by way of example, with reference to the accompanying drawings.

19. In combination, an electroluminescent display device according to any of the preceding Claims 1 to 15 and 17, and a circuit arrangement for operating the device, wherein at least part of the circuit arrangement, in the form of printed circuits carried on chips of insulating material, is mounted on the same substrate as the display panel and the associated leads, transverse conducting strips and contact areas, and is enclosed in the display encapsulation.

For the Applicants,
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1 467 738 COMPLETE SPECIFICATION
2 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

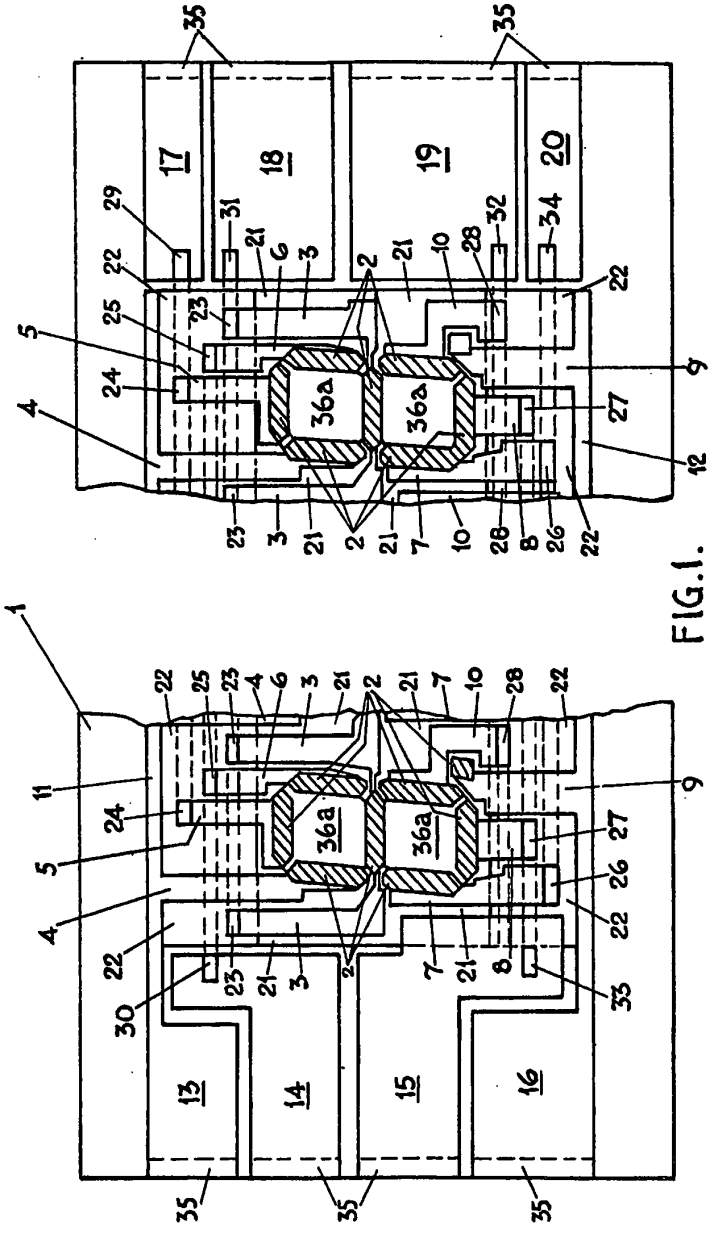

FIG.1.

1 467 738 COMPLETE SPECIFICATION
2 SHEETS

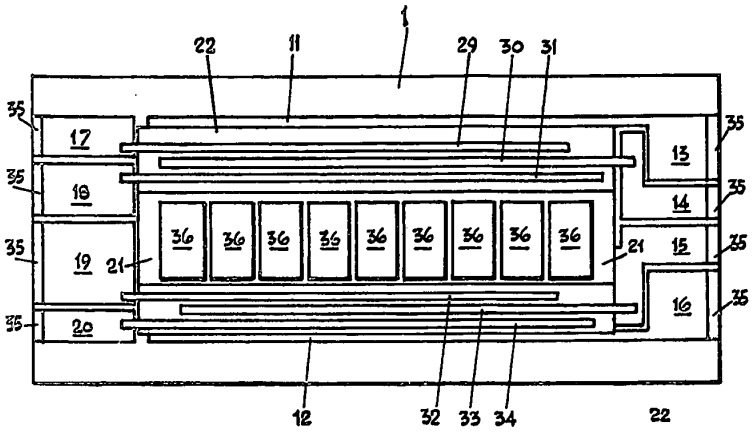

FIG.2.

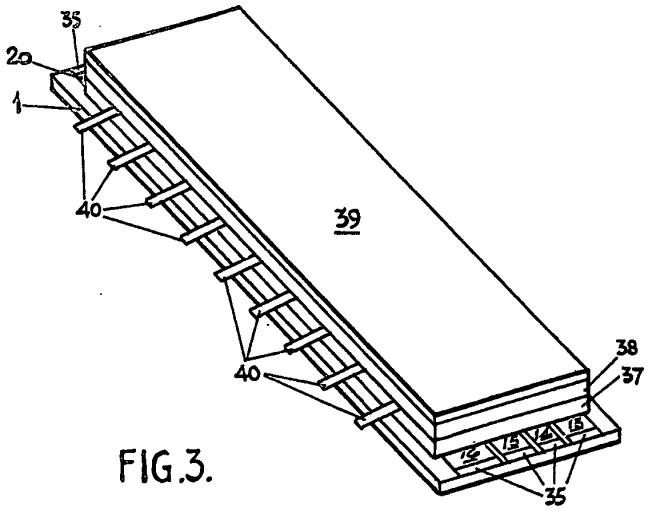

FIG.3.